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UNIVERSITY OF NEVADA - RENO - NEVADA - 89557

Mackay School of Mines
Seismological Laboratory

Telephone (702) 784-4975

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

We summarize contract work in connection with seismic discrimination. We have attempted to find a body wave-surface wave discriminant based on close-in data of NTS events. This endeavor now seems difficult to attain. We have done supporting work in terms of data recovery (high-quality digital data records of about 100 earthquakes and several nuclear explosions), extension of existing explosion source theory (to try and explain how, for a single explosion, the time history could appear different at different distances), and in creating theoretical seismograms for comparison with close-in (8 km) accelerometer data.

1. TECHNICAL REPORT SUMMARY

The purpose of this contract was to investigate a collection of close-in (5 to 50 km) seismic observations made over the years by the USGS in Las Vegas. The data set is unique, in that wideband (0.1 to 25 Hz), high-quality analog information is available for hundreds of explosions and several earthquakes on Nevada Test Site (NTS). This permits comparisons between the two classes of events through detailed investigation of their respective source characteristics. A specific goal was to investigate body waves and surface waves at these close distances so that the body wave-surface wave seismic discriminant (or Ms:mb discriminant), so effective at teleseismic distances (Evernden et al., 1971) and near-regional distances (McEvilly and Peppin, 1972; Peppin and McEvilly, 1973) could be followed down to small magnitudes. This point is relevant to a fundamental understanding of why the Ms:mb discriminant is so effective, because some authors (e.g. Aki et al., 1974) have predicted that the discriminant should disappear at small magnitudes.

This report summarizes our efforts toward meeting these research goals. We have not been successful in our primary goal, and the reasons for this are discussed in Section 2. In Section 3 we describe efforts which have enhanced and supported our fundamental studies of seismic sources. In Section 3.1 is a description of the Seismological Laboratory digital processing system, which will play a central role in contract work for DARPA/AFOSR in FY 1978-1980; in Section 3.2 we describe five excellent data sets which should be sufficient to test thoroughly the use of moment tensor analysis for near-regional determination of seismic source functions; in Section 3.3 we describe a now-operational, major computer program which guarantees that the moment tensor analysis can go forward; in Section 3.4 we describe a revision of Peppin's (1977) scaling law for explosions fired in tuff; in Section 3.5 we discuss a study of amplitude-yield scaling made for Lawrence Livermore Laboratory.

2. FRUSTRATION OF THE PRIMARY RESEARCH OBJECTIVE

Our primary research goal--to investigate the Ms:mb discriminant at close distances--has been hampered by three difficulties: (1) the data became available when only 11 months were left on this 28-month contract; (2) the data has been found to have inadequate dynamic range; (3) the available earthquake data is less adequate than it first seemed for comparative purposes with explosions. Each of these difficulties is discussed below.

2.1. Late Acquisition of Data

Due to a series of inexplicable misunderstandings, work with the USGS data set was begun in November, 1977 (contract initiation time July, 1976). This misunderstanding involved security requirements: access to the data could have begun much sooner, it was only the yields and gain settings on the USGS instruments that were classified. Digitization of 250 analog records began in December, 1977 and was completed three months later with the kind cooperation of the Seismographic Station of the University of California at Berkeley (We have no capability here to play back one-inch analog tapes). Plots and spectra were computed on the Seismological Laboratory digital processing system. These included records of only two earthquakes that occurred on the test site: the Massachusetts Mountain earthquake of August, 1971 (three-component records at 14 stations in and near the test site) and the March 1973 Ranger Mountain earthquake (3-component records at six stations in and near NTS). The underground test MILKSHAKE was selected for comparative analysis because it occurred within 10 km of each earthquake and because a fair number of three-component records were available for it (Figure 1).

2.2. Data Possesses Insufficient Dynamic Range

First arrivals on the close-in records were very strong; however, to study ten-second surface wave energy, we needed to be able to separate them from the large short-period energy that dominates these close-in records. The plan here was to compare 10-second energy so obtained with the near-regional studies of surface-wave energy of similar period. Digital low-pass filtering was done on the MILKSHAKE records at Station CP-1 (Figure 1). A clear 3-second Rayleigh wave was seen on the vertical and radial components (Figures 2 a,b), but signal-to-noise ratio is inadequate at 10 seconds (Figures 3 a,b). What is worse, no sign of long period above the noise at all for the Ranger Mountain earthquake is seen (Figures 4 a.b and 5 a,b).

Now for these same events clear 10-second energy can be seen at near-regional distances at the Lawrence Livermore Laboratory stations MNV, KAN, LAN, and ELK. The absence of such energy here implies that system dynamic range is inadequate. Recently, we have acquired some excellent data of much better quality for the EMMENTHAL (overburied) test on Pahute Mesa recorded at a site near CP-1 (see Section 3 below); the greater dynamic range of these digital records will permit a more critical search for 10-second surface-wave energy. A major problem is that close-in, the three-second energy is very large compared with the 10-second surface waves (the short-period energy is trapped in the very slow surface layers due to the shallow depth of the source). Such energy dies out at near-regional distances and permits detection of the long-period waves using analog recordings there with dynamic range characteristics comparable with the USGS L-7 systems on the test site.

2.3 Earthquake Data is Marginally Adequate

Before the publication of Navarro's (1977) excellent report, it was very difficult to determine what data the USGS in Las Vegas had; different people there gave different versions of what was available. Early on, I was told that aftershocks of the Pahute Mesa explosion BENHAM had been recorded on the USGS L-7 instruments; this extra data would have made the comparative studies I was proposing much more meaningful (dozens of large aftershocks covering a sizeable area of Pahute Mesa). The BENHAM data was either lost or never existed, which leaves only the data on the two earthquakes mentioned above.

In spite of these difficulties, we can still perform some processing of interest on the numerous explosion records: amplitude-yield scaling; shape of the explosion source function; moment tensor analysis. This work will go on in the present AFOSR contract period. The work has taken on an urgency, because the USGS in Las Vegas is disbanding. I intend to pull out as much data as I can before the man who knows it best--Richard Navarro--leaves. I am building a library of digital data here in Reno with the idea of providing access to other AFOSR contractors who are interested.

3. WORK SUMMARY 01 JULY 1976 TO 30 SEPT 1978

3.1. Development of the Seismological Laboratory DPS

AFOSR has made a significant contribution--$20,000 in salary money and $13,750 in equipment--toward the establishment of a modern digital processing system (DPS) at the Seismological Laboratory (total investment to date beginning in 1973: $45,000 for salaries and $65,000 for equipment). The system includes a PDP 11/34 computer with 64 Kwords of memory, dual RK05 discs, TU10 magtape, Tektronix 4013 graphics terminal with digitizing tablet, Houston Instruments DP-3 incremental plotter, and Versatec printer-plotter. Two operating systems are available: RSX11-M, Version 3.1 (provided by Digital Equipment, this is the choice for real-time problems and number-crunching) and UNIX, the ingenious system from Bell Labs which is now used mainly for instruction and text processing (preparation of this report, for example). In addition, a large complement of software has been written to process data recorded by the state-of-the-art digital event recorders built here with other AFOSR support. The system now stands ready for heavy and productive use on present contract work; some 5 Mbytes of digital event recorder data is available on random-access disc files. The machine is being used by five members of the Lab almost seven days a week.

3.2. Data Acquisition

The seismic digital event recorders, built at the Seismological Laboratory with funding from three other AFOSR contracts, have provided an imposing library of highest-quality data for studying seismic sources. Designed for use in the AFOSR-sponsored Near-Field Project, they have characteristics ideal for recording close-in and near-regional data. Here we describe five data sets acquired which provide the basis for a comprehensive study of the earthquake and explosion source. These will provide, together with the USGS data, the basis for a thorough evaluation of the moment tensor method for seismic sources (Stump and Johnson, 1977).

3.2.1 03 Sept 1978 Diamond Valley sequence

On 03 September 1978 an earthquake of magnitude 4.5 occurred in Diamond valley, 14 km S of Carson City. A single digital event recorder (DER) was set out for 4 days during which 60 3-component records were obtained. Many of these events occurred almost directly below the recording site (Figure 6). The Seismological laboratory maintains a fairly dense array of permanent stations around the source region for hypocentral and focal control of these events.

3.2.2. The Geysers geothermal region

From 20 Nov to 04 Dec 1977 we deployed three DERs in a small array 10 km S of The Geysers geothermal production field, over an ongoing sequence of natural earthquakes. The idea was to record and compare two classes of events: (1) those induced by acts of man, and (2) naturally-occurring earthquakes. 150 excellent-quality records were used to compare spectral/analog parameters of these two classes of events, with an idea toward finding a _seismic discriminant_ between them. Here our aim is to understand better the phenomenon of an earthquake as a seismic source. Results so far are rather definitive and negative (Figures 7-9 from Peppin and Bufe, 1978).

3.2.3 The Bishop, California sequence of 04 October 1978

The occurrence of a sizeable earthquake in the Sierra Nevada was an exciting prospect, because an opportunity was provided to record on excellent, granite sites right over the source region. Two DERs were deployed for 5 days over the epicentral region. The seismometers literally rested on the granite bedrock. Two earthquakes were recorded satisfactorily on both sites (Figures 10,11), providing the necessary six components for full moment tensor inversion. The records are surprizingly complex considering the near-vertical travel paths from source to receiver and (presumed) homogeneous nature of the intervening rocks.

3.2.4 The October, 1978 Mono Lake sequence

During the Bishop sequence, a DER was set at Mina to provide near-regional records of earthquakes. The Bishop events were too small to trigger the machine; however, also during this time an earthquake swarm occurred E of Mono Lake, providing data for 20 events. These will be used for studying near-regional depth discriminants by Alan Ryall with the permanent Nevada network stations for control.

3.2.4 Close-in recordings of the EMMENTHAL and FARM tests

On 02 November 1978 the EMMENTHAL underground nuclear test was fired on the east end of Pahute Mesa. Because the shot was overburied, we set out three DERs on near-regional distances. The hope here was that, with good-enough data, we could pick out the effects of overburial on the seismic signals recorded. Data acquisition was successful: we obtained digital, 3-component data at Mina, 200 km NW, Beatty, 60 km W, and CP-55, 40 km S of the shotpoint. Digital Records obtained at Mina are nearly overlays of those obtained by the Lawrence Livermore Laboratory on their continuous-recording, analog, wideband station MNV, in a tunnel 1/4 mile south of our instruments. Records written at CP-55, a hardrock site on the test site and one of Navarro's standards, show very high excitation of near-surface sediments (modal wave propagation even this close: Figure 12). The most interesting records were obtained at Beatty in a mine adit (Figure 13). Here we note the tremendous size of the S-phase on the horizontals, markedly larger than the energy from P. This shot must have excited considerable S-wave energy at the source. This is unexpected, because the shot was overburied, thus, presumably possessing of greater spherical symmetry at the source (smaller free-surface effect). The S is also large at one of the other LLL stations, LAN, S of the test site.

Because of the anomalous S at Beatty, we recorded in the same adit for the FARM test of 16 Dec 1978, also on Pahute Mesa. The S-phase is much less evident (Figure 13.5).

Brian Stump made close-in (less than 10 km) digital recordings of both EMMENTHAL and FARM; our desire is to compare sourcce characteristics using either his close-in data or our near-regional data. This will be a major research goal in my present AFOSR contract.

3.3. Wave-Propagation Code

Just as this contract concluded, I was finally able to bring up my program to do exact seismic wave propagation from a buried explosion in an elastic, layered halfspace. The solutions involve no asymptotic expansion, and thus can be applied in the near-field (one wavelength or less) range. The code is easily generalizable to all second-order seismic sources, and so can produce Green's functions for Brian Stump's moment tensor inversion code. This is important, because in his close-in work with NTS data, Brian is now convinced that he needs to include layering in the medium.

I show here some comparisons of the data with theoretical seismograms recently made using the new code. In Figure 14 we see the theoretical response for the vertical component before and after convolution with the instrument/time history (top traces) and can compare with the bottom trace (data from JORUM-HANDLEY at 8 km: Peppin 1977). The radial component is shown in Figure 15.

The comparison of theory with data is only fair; but the theoretical seismogram is obviously very sensitive to the structure above the source. It appears that I can get a better fit by simply making the top layer thinner. Then, finally, if I add a deep reflector I will be able to get converted S, thus explaining the later arrivals seen in the data of that phase.

In summary, it looks like we will be able to fit the vertical and radial data very well without recourse to a source more complex than a pure explosion. More careful analysis will soon be underway jointly with Brian Stump using moment tensor analysis. Note also--it is not clear, as Helmberger says, that overshoot at the source is required to explain these observations. The time history used here had no overshoot, and note the good agreement in wave shape with the observed radial first cycle.

3.4. Scaling Law Revision

In Technical Report No. 2 for this contract I described a modification of Peppin's (1977) source model for a nuclear explosion in tuff. This revision was made to provide a mechanism through which the time history of an explosion would appear steplike in the near field and impulsive in the far-field (at teleseismic distances). The hope was to explain the fact that close-in analysis (Werth and Herbst, 1963; Rodean, 1971; Murphy, 1977; Peppin, 1976) seem to imply a steplike time history for explosions, while teleseismic analyses (Molnar, 1971; Burdick and Helmberger, 1973) seem to indicate an impulsive time history. The attempt was partially successful. Significantly, the model requires for an explosion source something in addition to the classical spherical pressure-pulse component, consistent with Viecelli (1973), Bakun and Johnson (1973), Springer (1974), Peppin (1977), and Stump and Johnson (1978), but contrary to Burdick and Helmberger and to the extremely regular and simple waveforms of explosions routinely seen at teleseismic distances.

3.5. Amplitude-Yield Scaling of Chemical Explosions

In 1978 and under another contract, I investigated amplitude-yield scaling relations of seismic waves caused by above-ground chemical explosions. Observations were made 1 to 3 km away using 3 DERs for 46 explosions. A noteworthy point about this experiment was that we exerted quite rigid control over the placement and yield of the explosions, so that some important lines of research could be studied. Of pertinence to this contract were two: the source-coupling effect and amplitude-yield scaling.

3.5.1. Source coupling

To investigate source coupling, we fired a set of 8 fifty-pound charges in a pair of lines 300 meters long and at right angles. We found severe effects on all seismic measurements for sites as little as 25 meters apart (in excess of a factor of two variation in measured amplitude for charges of the same size). This is considerably less than the wavelength of 10-Hz waves recorded by the DERs, and vividly illustrates the well-known problem of source coupling factors also experienced in underground testing on NTS. In spite of this variation, we were able to develop an "average" source coupling factor that permitted estimates of six unknown chemical yields, placed at uncalibrated and unknown sites, to a precision not less than 20%.

3.5.2. Amplitude-yield scaling

Amplitude-yield scaling was accomplished by a set of 11 charges ranging from 25 to 525 pounds in weight, each fired on the same (to a precision of 1 meter) shotpoint. Several measurements were attempted in an effort to find the most effective seismic yield determinant (see Figure 16 for example). Three points are relevant for this contract: (1) the best yield determinant (i.e. least dependent on site and travel-path) was found to be the amplitude-spectral average near the corner frequency on the vertical component of ground motion (radial component almost as good, transverse component distinctly poorer). This determinant was significantly better than Springer and Hannon's (1973) "a" and "b" measurements (see Figure 16); (2) amplitude-yield scaling exponents "k" in the formula Amplitude = k log(Yield) + c were found to be comparable to those found by Springer and Hannon for the "a" and "b" values using near-regional data of far larger underground explosions on Nevada Test Site (see Table 1); (3) spectral corner frequency varies only slowly with yield from 25 to 525 pounds, so that cube-root scaling fails to apply to these shots (frequencies of up to 10 Hz seen 1 km from the source).

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5. FIGURE CAPTIONS

Figure 1: (see figure)

Figure 2: (see figure)

Figure 3: (see figure)

Figure 4: (see figure)

Figure 5: (see figure)

Figure 6: Recordings of the Diamond Valley earthquake of 5 Sep 1978 1636 GCT. The depth was 10 km and the epicentral distance was 2 km. In spite of this, note how complex are the waveforms. High-frequency noise on the NS component is believed to originate in air-coupled sound waves.

Figure 7: Spectral data from Peppin and Bufe (1978). Plotted are vertical P- and horizontal S-wave corner frequencies taken from digital records near The Geysers geothermal area. The main point of this and two subsequenct figures is that the induced events within The Geysers steam production field cannot be discriminated from naturally-occurring ones based on routine measurements.

Figure 8: Seismic moment versus Richter magnitude ML for events at and near The Geysers. Mo-ML curves differ far more among source areas than between man-caused and natural events in The Geysers region.

Figure 9: Seismic moment versus corner frequency for Geysers events compared with Imperial Valley data (the small dots). The variation between these two geothermal regions far exceeds the variation seen between natural and induced events at The Geysers. Dashed lines are estimates of seismic stress drop.

Figure 10: This is digital ground velocity for an aftershock of the Bishop earthquake of October 1978. The recording site is essentially on granite bedrock, thus the records should give a clear look at the source of the event. Source and receiver sites are in the Wheeler Crest granites. Epicentral distance is about 5 km.

Figure 11: Same earthquake as in Figure 10, but as seen at Rock

Figure 11: Same earthquake as in Figure 10, but as seen at Rock Creek, 10 km SW, also on hard rock. Shown is ground displacement. These six records together can be used in moment tensor analysis, providing unique ultra-wideband coverage of an earthquake.

Figure 12: EMMENTHAL as recorded at CP-55 on Nevada Test Site. Shown is ground displacement. The records are dominated by modal propagation in shallow, slow sediments. The direct arrival is almost absent (top trace: expanded version of the P-onset on the second vertical trace). The travel path skirts Yucca Valley, so the appearance of the records is unexpected.

Figure 13: EMMENTHAL as recorded at Beatty. Shown is ground velocity. Of considerable interest is the tremendous S-wave from this shot. This would not be expected from an overburied explosion. The record is of fantastic quality: signal amplitude 20,000 counts and noise amplitude 0-10 counts from 10 seconds to 50 Hz.

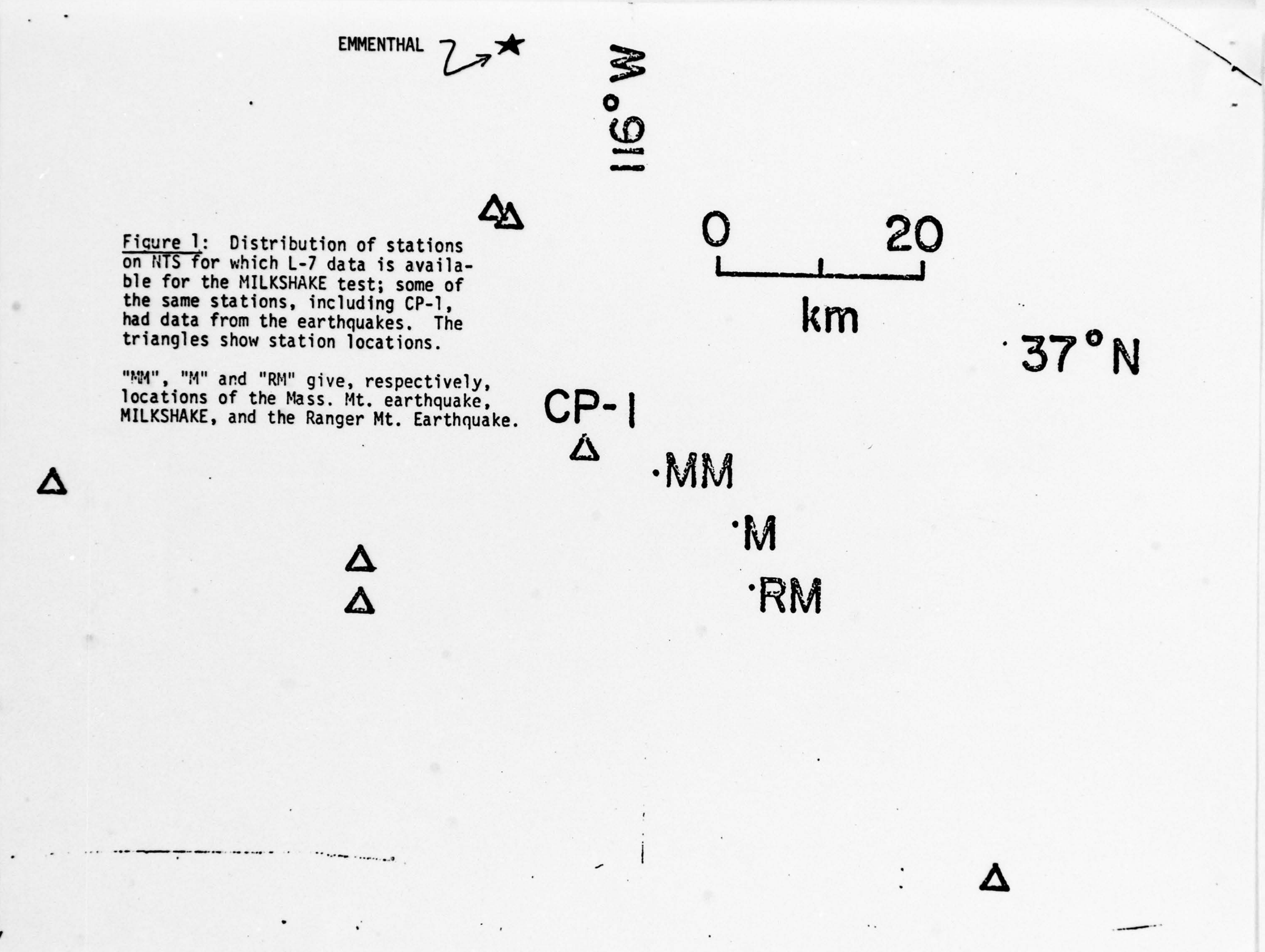
Figure 13.5: FARM as recorded at Beatty, ground displacement. The sawtooth appearance is probably caused by clipping in the preamplifier (this was a large explosion). However, the free period was set to 15 seconds, so the long-period information should still be good. This record appears not to show a large S-wave as was found at the same site for EMMENTHAL. Long-period noise on the horizontal component was caused by wind currents.

Figure 14: Comparisons of predicted ground acceleration with observed at 8 km from JORUM-HANDLEY, vertical component: pure explosion in a halfspace below a layer. Top trace: the Green's function; second trace: Green's function through accelerometer; third trace: after convolution with a 1/2 second pulse to simulate source finiteness; bottom trace: data. Clearly with model adjustment we can improve the fit. Of significance: the simple explosion source alone can satisfy the data.

Figure 15: Same format as Figure 14 for the radial component. In spite of Helmberger's statements, it appears that these data do not require overshoot at the source. My work will thus lead to slightly different conclusions about the source than

Helmberger's.

Figure 16: Amplitude-yield scaling relations obtained from digital records taken at 3 km distant from above-ground chemical charges of the yields indicated. It is of interest to note that the scaling relations for "a" and "b" agree fairly well with those found by Springer and Hannon (1973) at distances 100 times greater. Note that spectral yield determinants seem to give slightly better results. Numerical data is summarized in Table 1 following the figure.



<u>Figure 1</u>: Distribution of stations on NTS for which L-7 data is available for the MILKSHAKE test; some of the same stations, including CP-1, had data from the earthquakes. The triangles show station locations.

"MM", "M" and "RM" give, respectively, locations of the Mass. Mt. earthquake, MILKSHAKE, and the Ranger Mt. Earthquake.

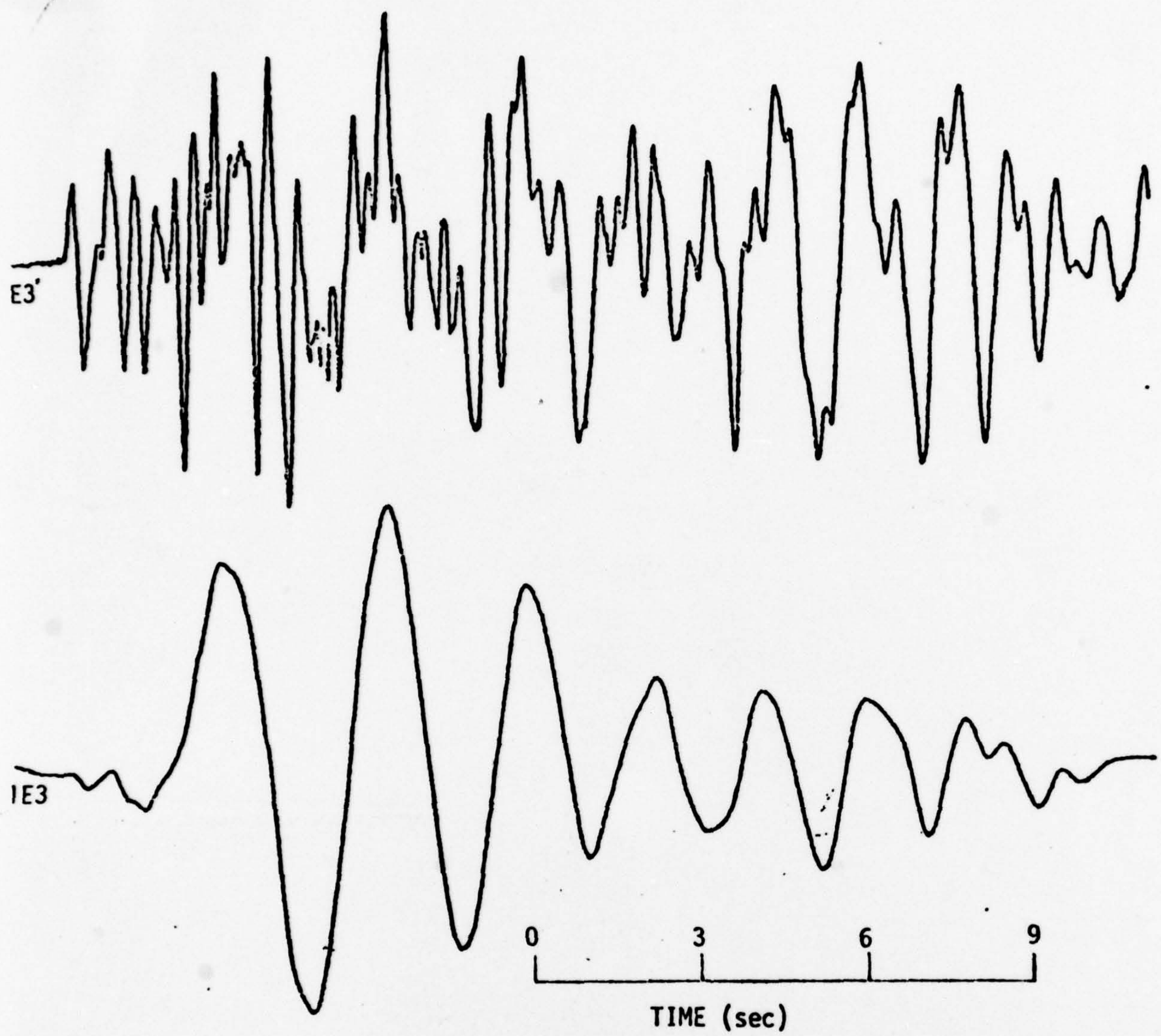


Figure 2a: MILKSHAKE vertical component, raw data on the top trace, and low-pass filtered (less than .33 Hz) on the bottom trace. The numbers denote the relative amplitudes of each trace: note how much smaller the surface wave is than the raw data trace. This and all subsequenct images are data recorded at station CP-1. Note Rayleigh motion on this trace and the radial component, Figure 2b.

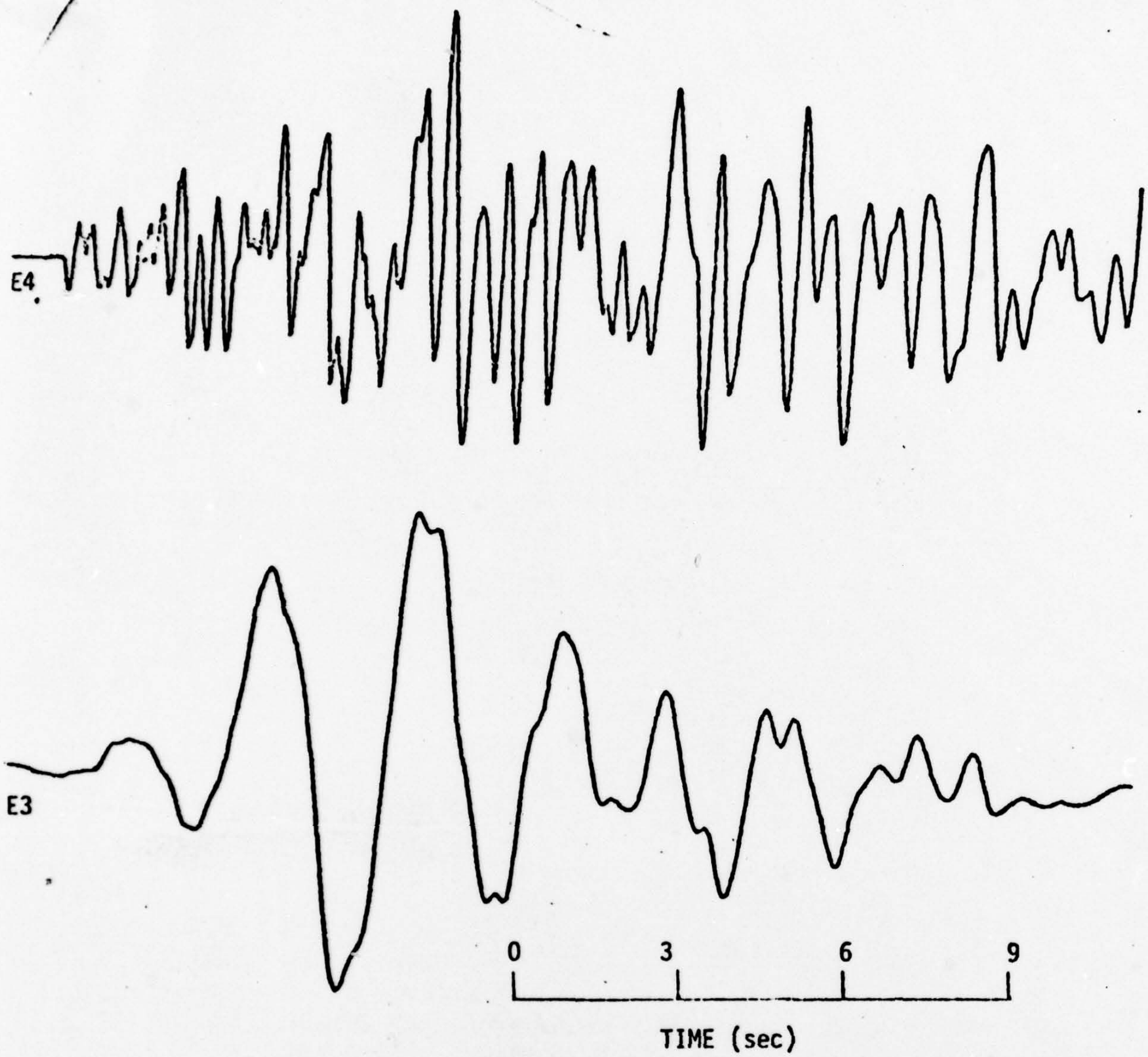


Figure 2b: same format as 2a, but radial component.

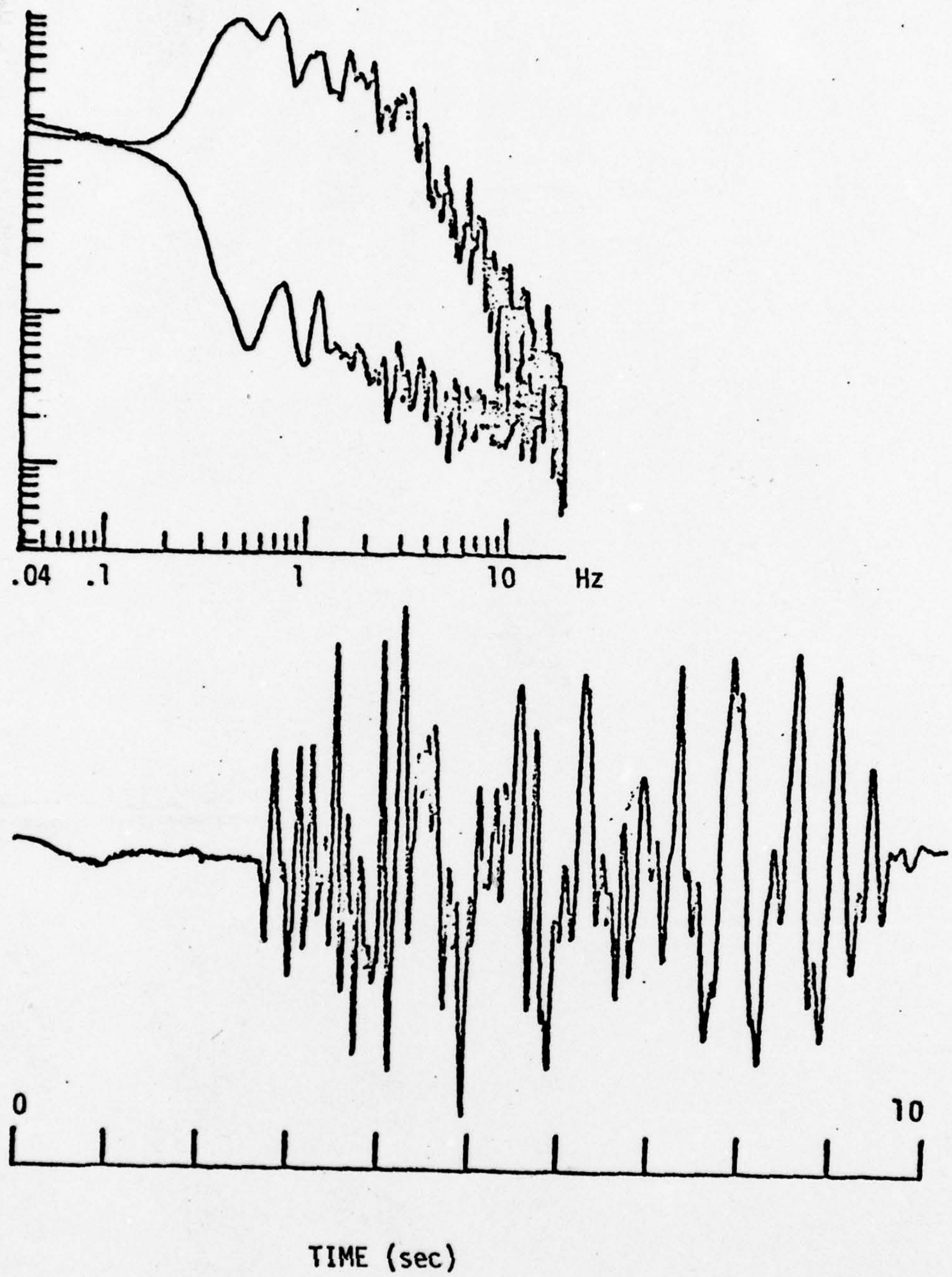
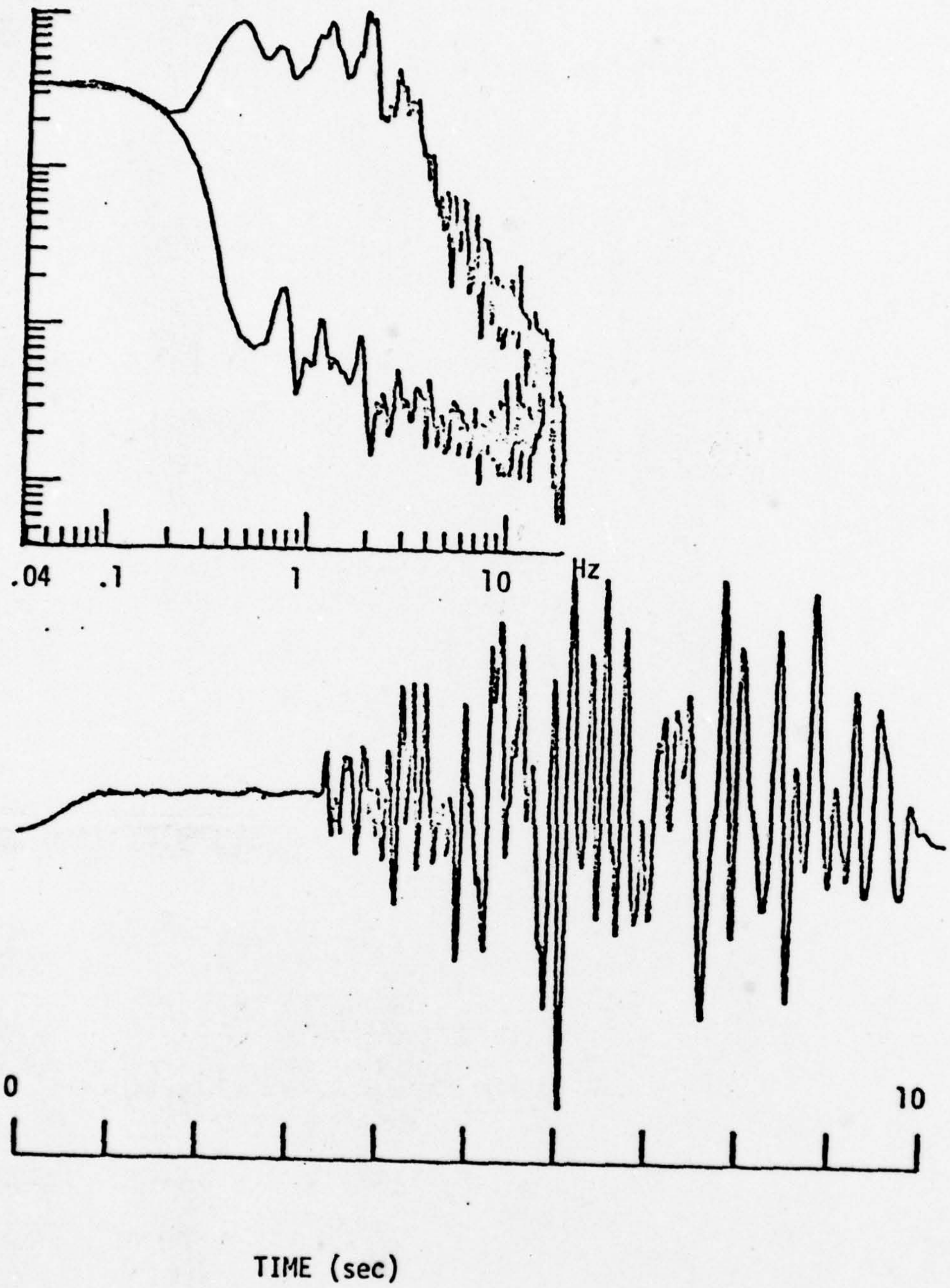


Figure 3a: Fourier amplitude spectrum of MILKSHAKE, vertical component, as seen at station CP-1. The lower trace is the signal that was processed (note cosine tapering), and the upper plot shows the spectrum. In the upper plot, the lower line is an estimate of the noise, got by identical processing of the quiet segment of record preceding the event onset. Spectral ordinate is in volt-cm.



<u>Figure 3b:</u> same format as Figure 3a, but the radial component.

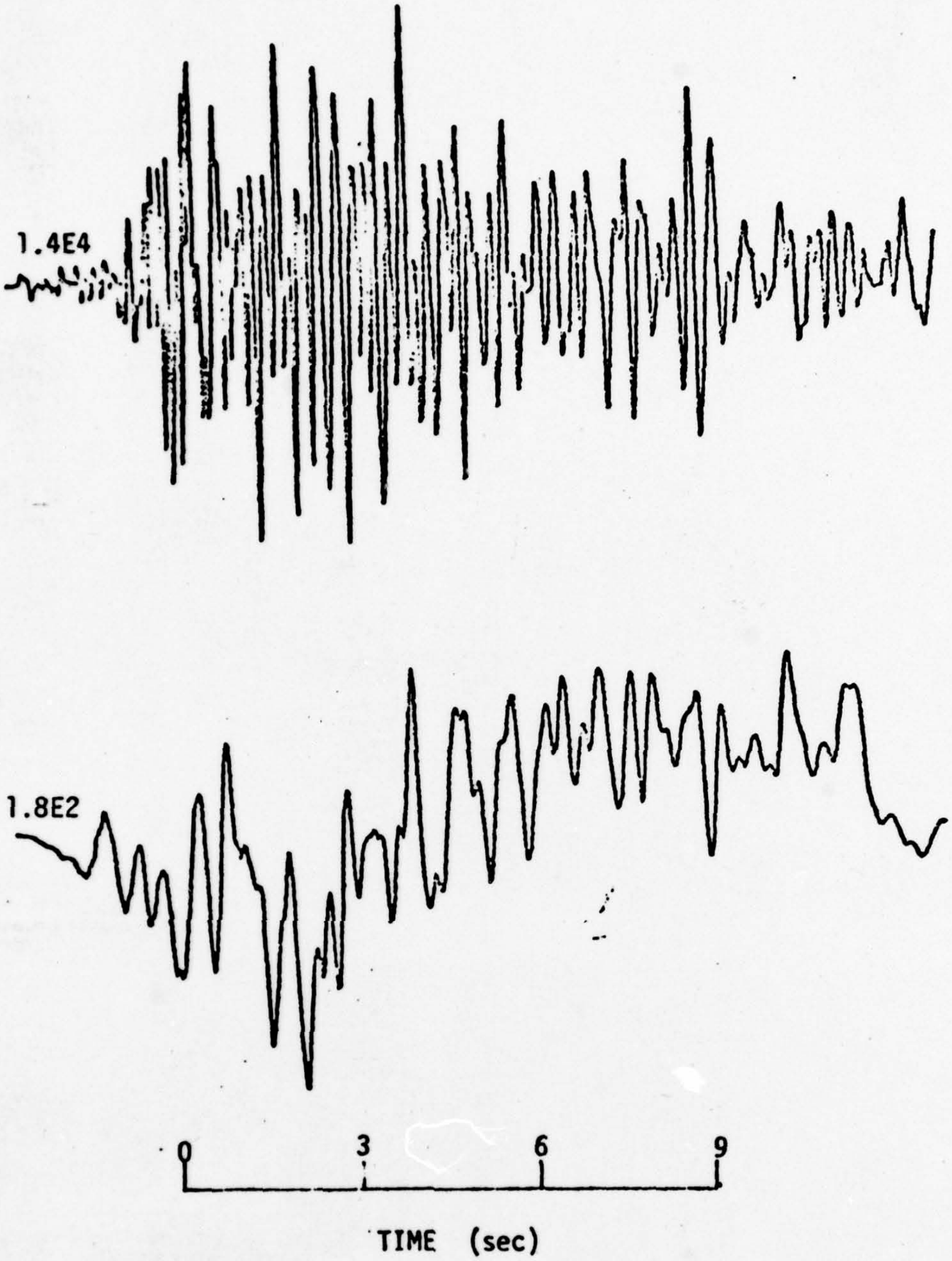


Figure 4a: same format as Figure 2, but for the Ranger Mountain earthquake as seen at station CP-1. Vertical component.

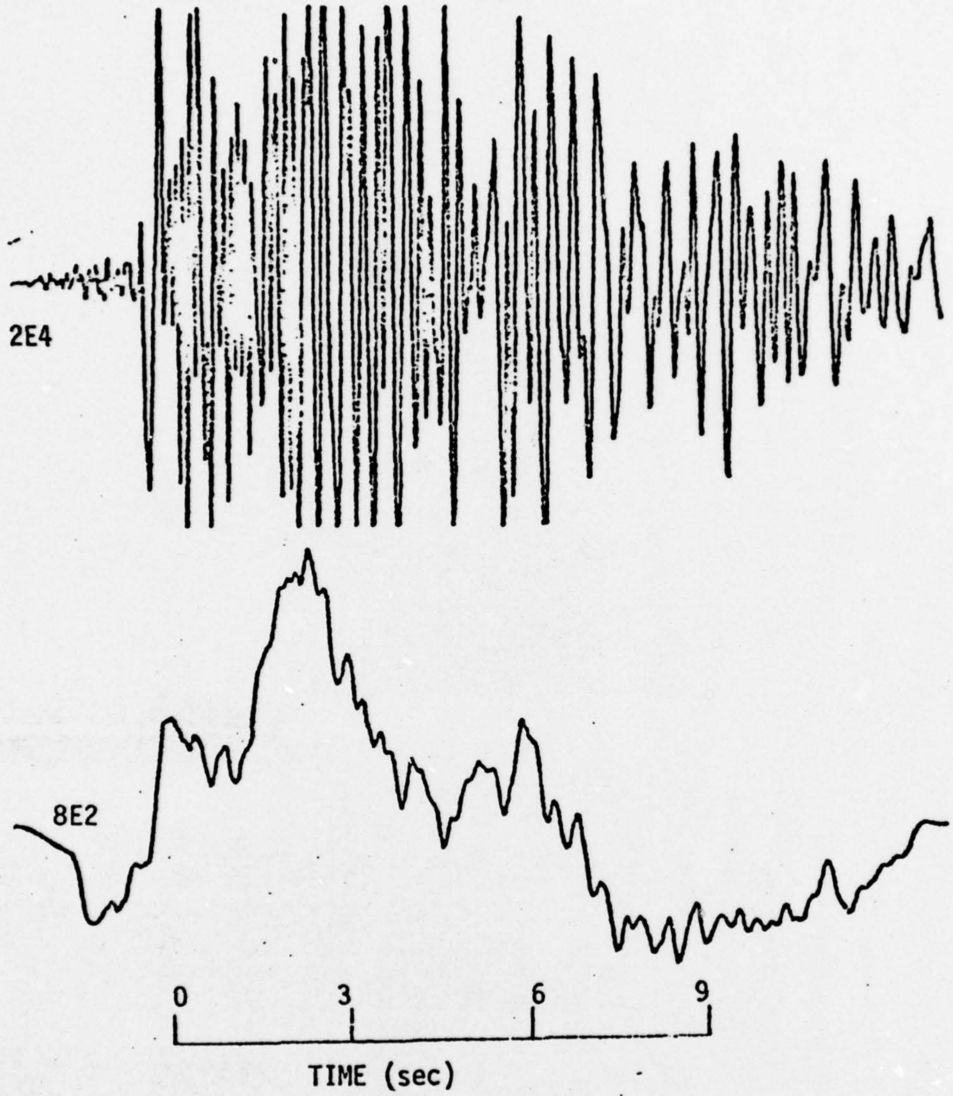


Figure 4 b: same format as 4 a, radial component.

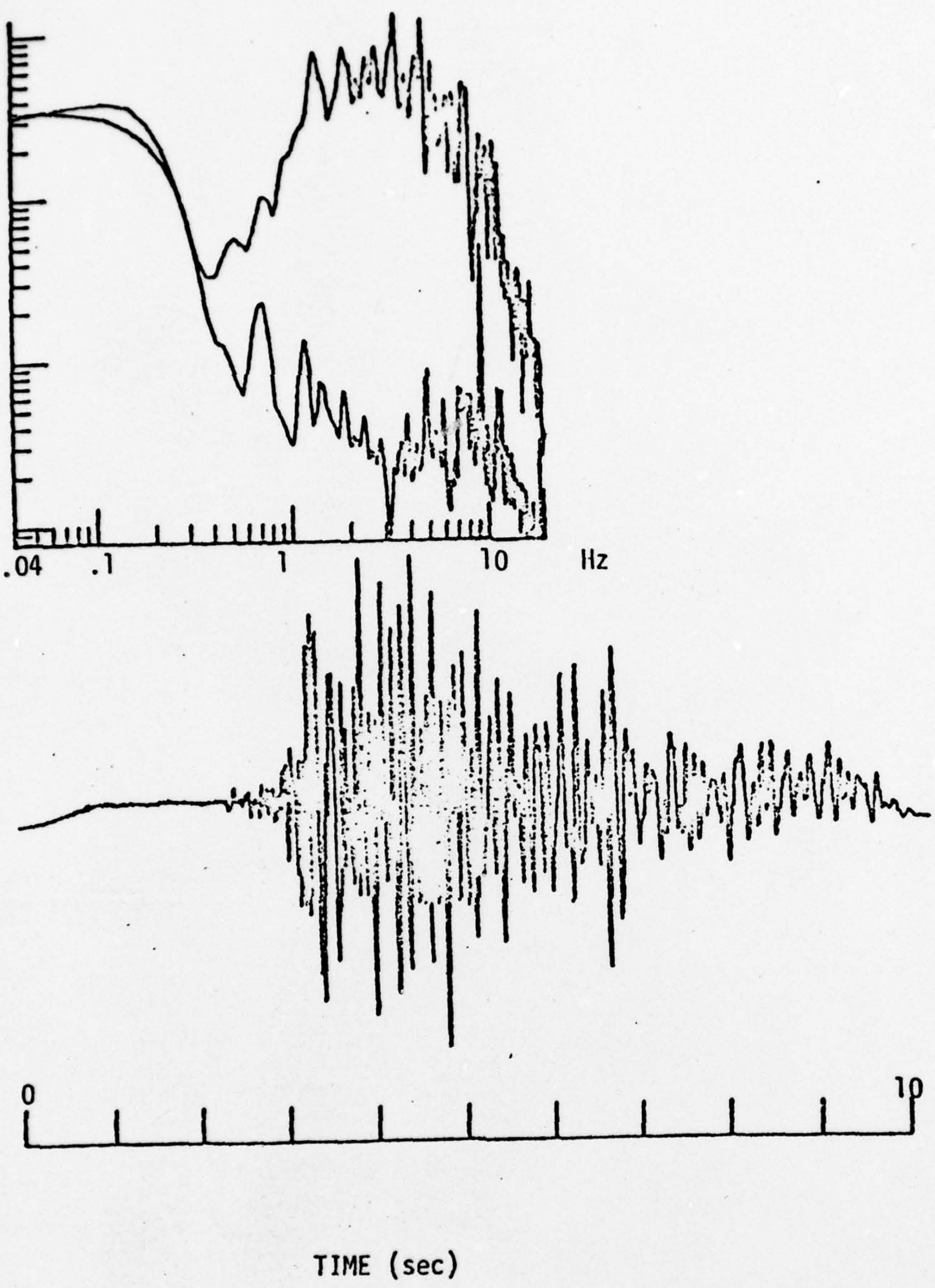


Figure 5a: same format as Figure 3, but for the Ranger Mountain earthquake, vertical component, at station CP-1.

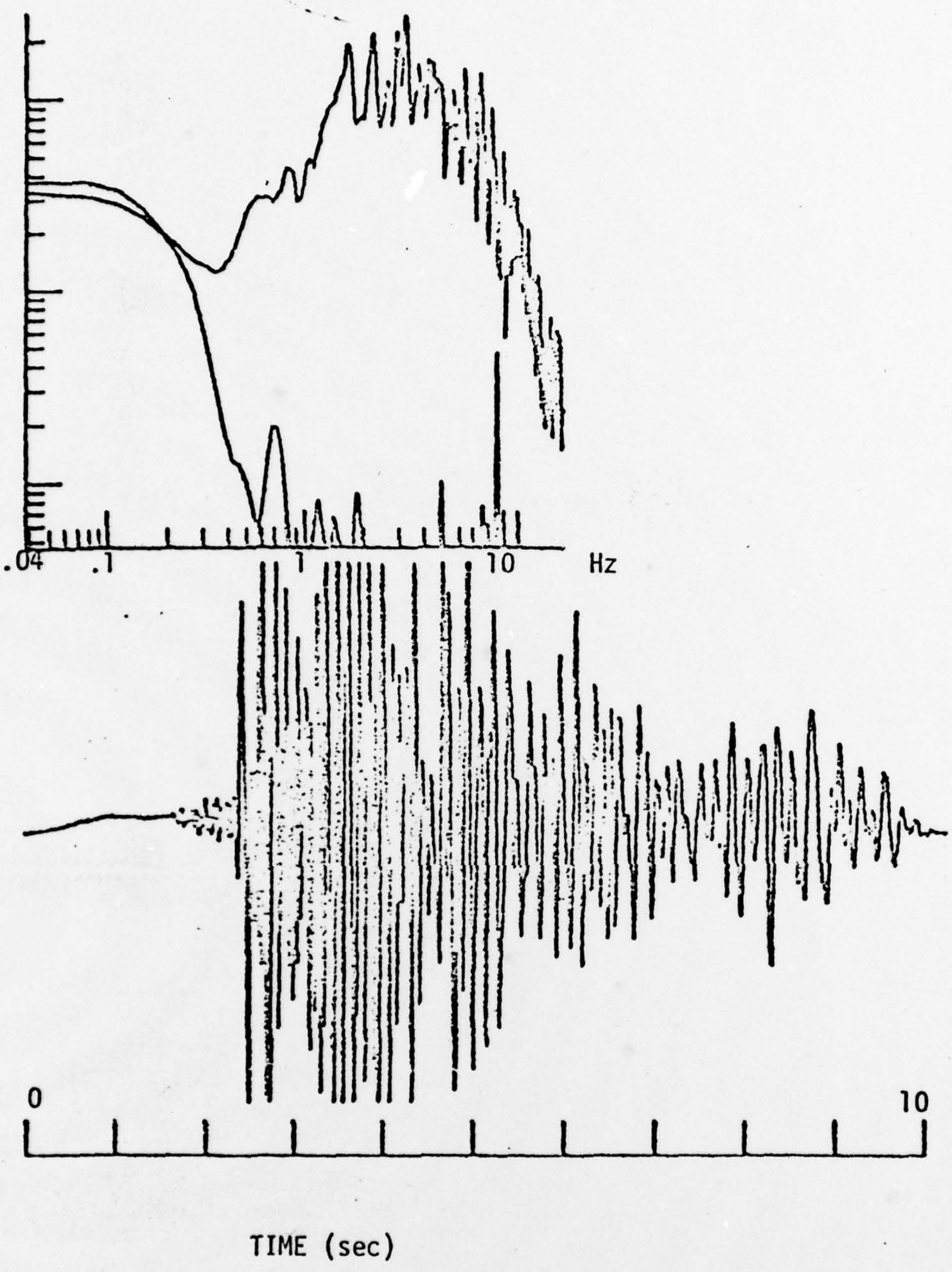


Figure 5b: same format as 5a, radial component.

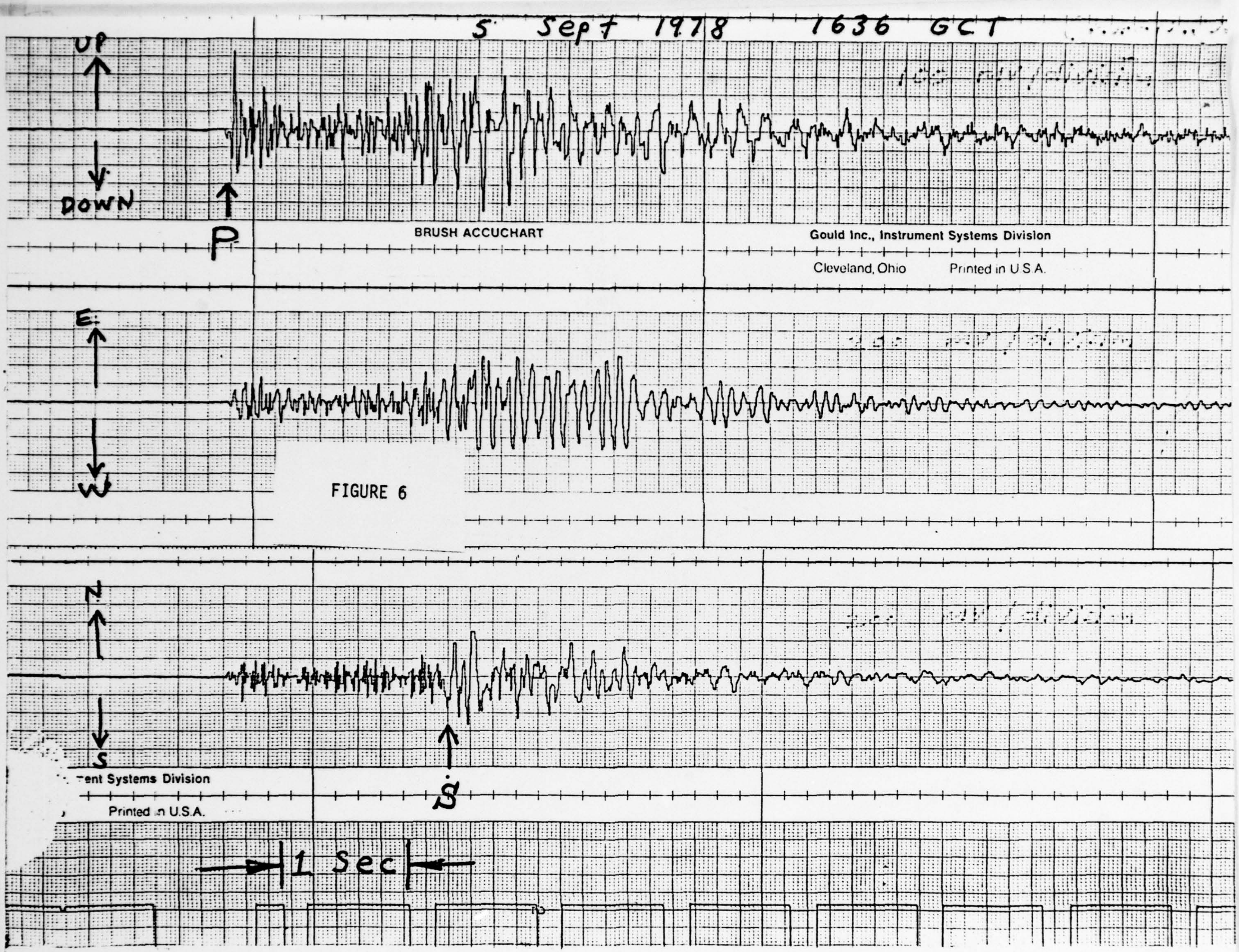
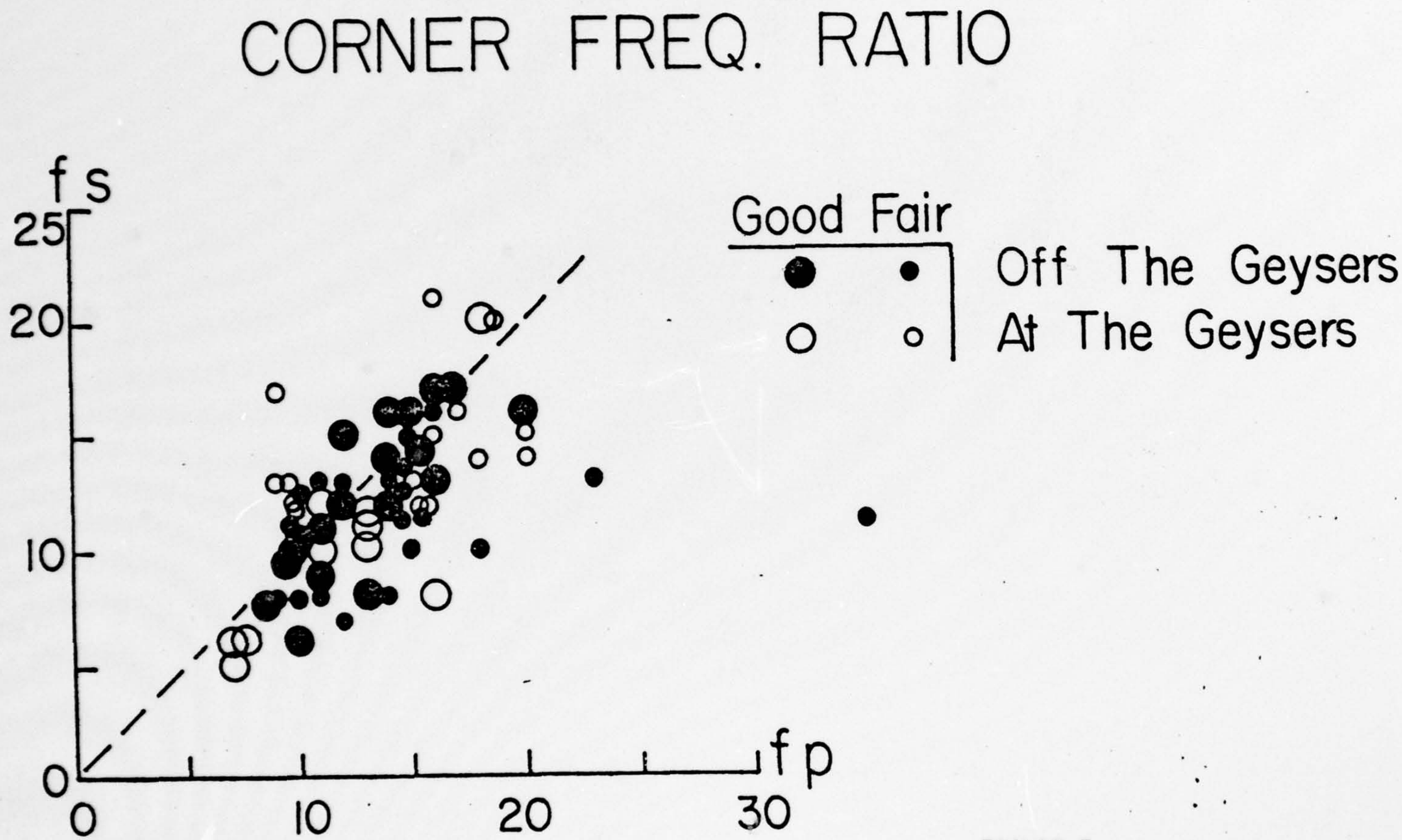
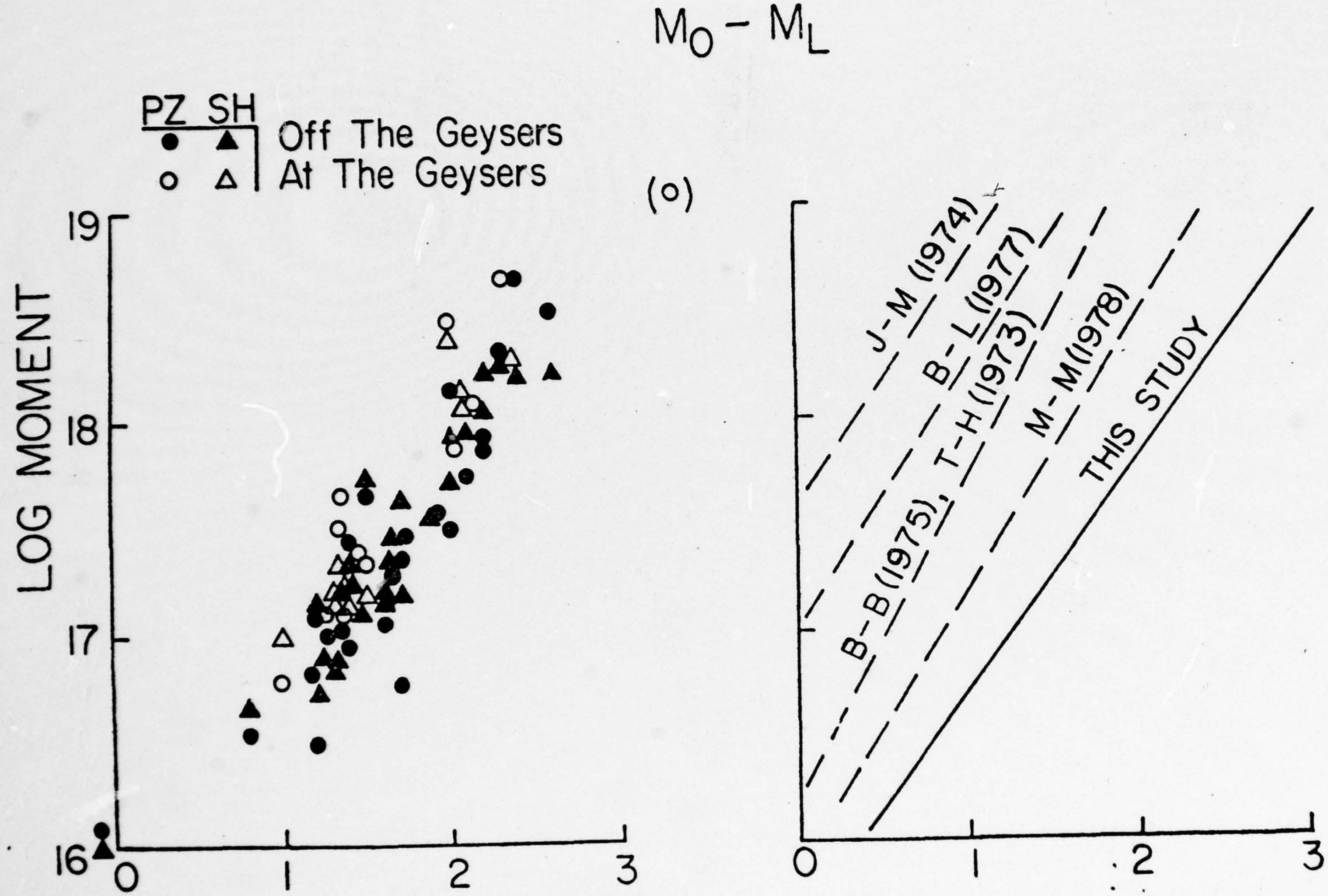

5 Sept 1978 1636 GCT
UP
DOWN
P
BRUSH ACCUCHART
Gould Inc., Instrument Systems Division
Cleveland, Ohio
Printed in U.S.A.
E
W
N
S
S
ent Systems Division
Printed in U.S.A.
1 Sec

FIGURE 6



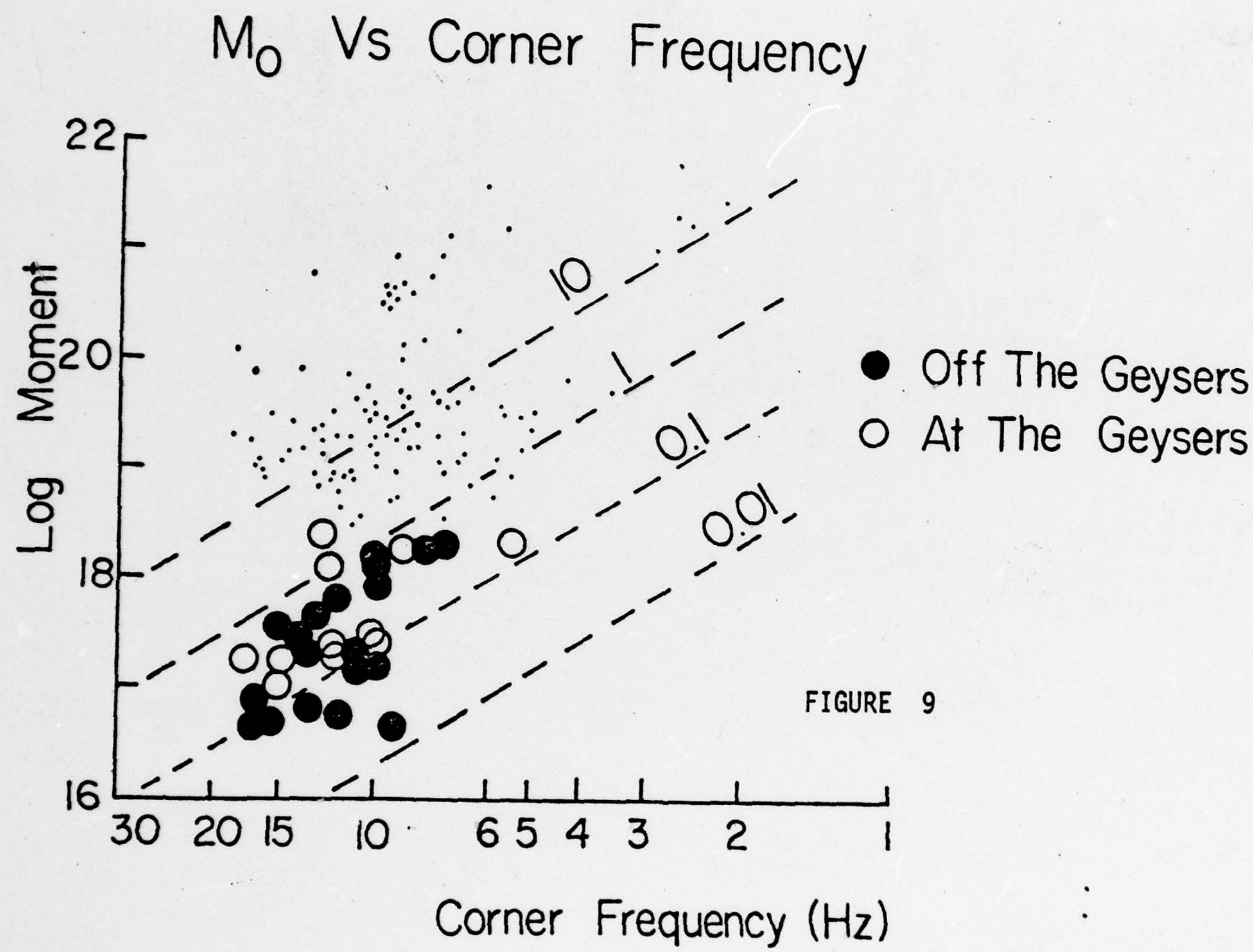
CORNER FREQ. RATIO
f s
25
20
10
0
0
10
20
30
f p
Good Fair
Off The Geysers
At The Geysers

FIGURE 7



$M_O - M_L$
PZ SH
Off The Geysers
At The Geysers
LOG MOMENT
19
18
17
16
0
1
2
3
MAGNITUDE
(o)
J-M (1974)
B-L (1977)
B-B (1975), T-H (1973)
M-M (1978)
THIS STUDY
0
1
2
3
M_L

FIGURE 8



M_o Vs Corner Frequency
Log Moment
22
20
18
16
10
1
0.1
0.01
Off The Geysers
At The Geysers
30
20
15
10
6
5
4
3
2
1
Corner Frequency (Hz)

FIGURE 9

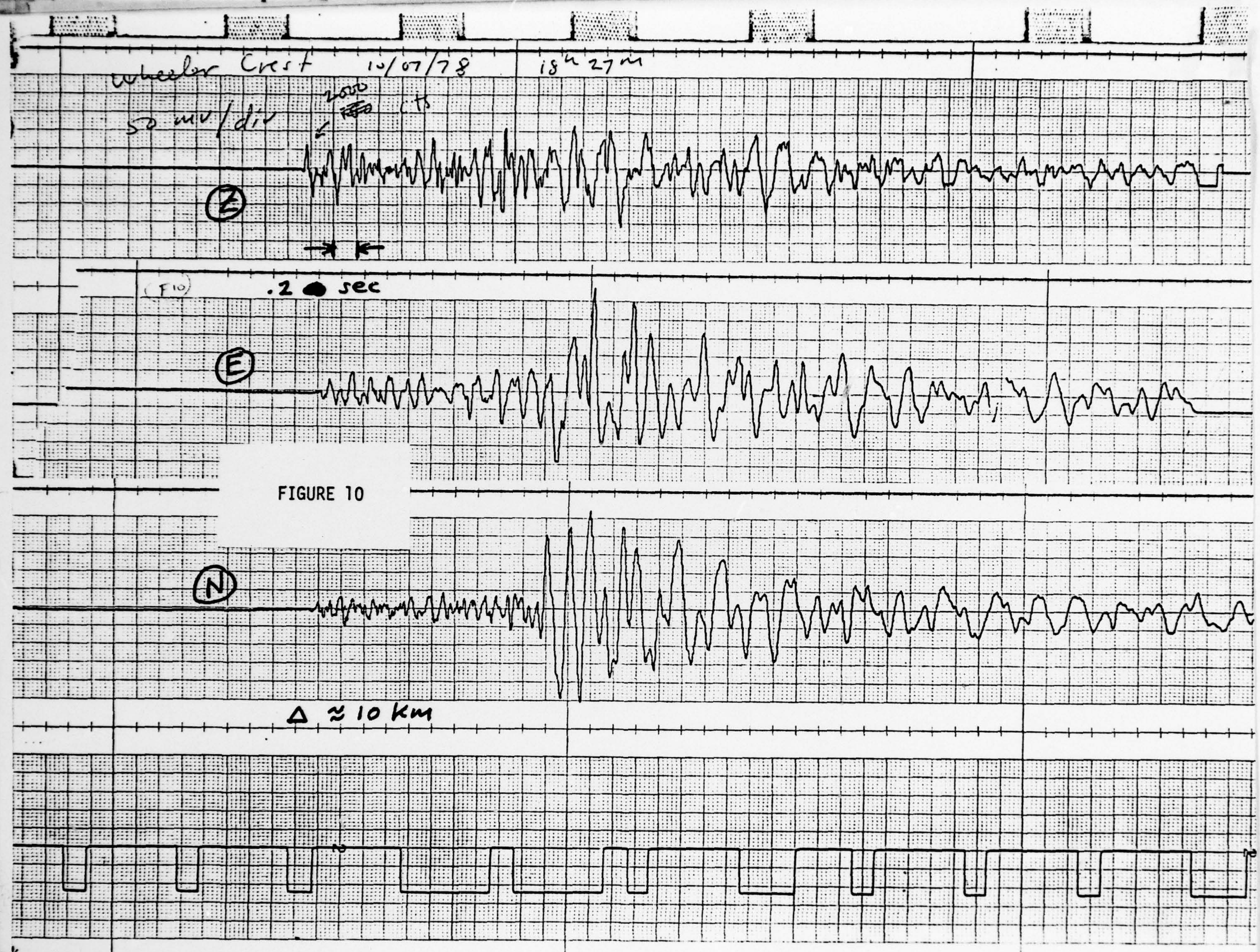

Wheeler Crest 10/07/78 18h 27m
50 mv/div
2000 cts
Z
.2 sec
(F10)
E
N
Δ ≈ 10 km

FIGURE 10

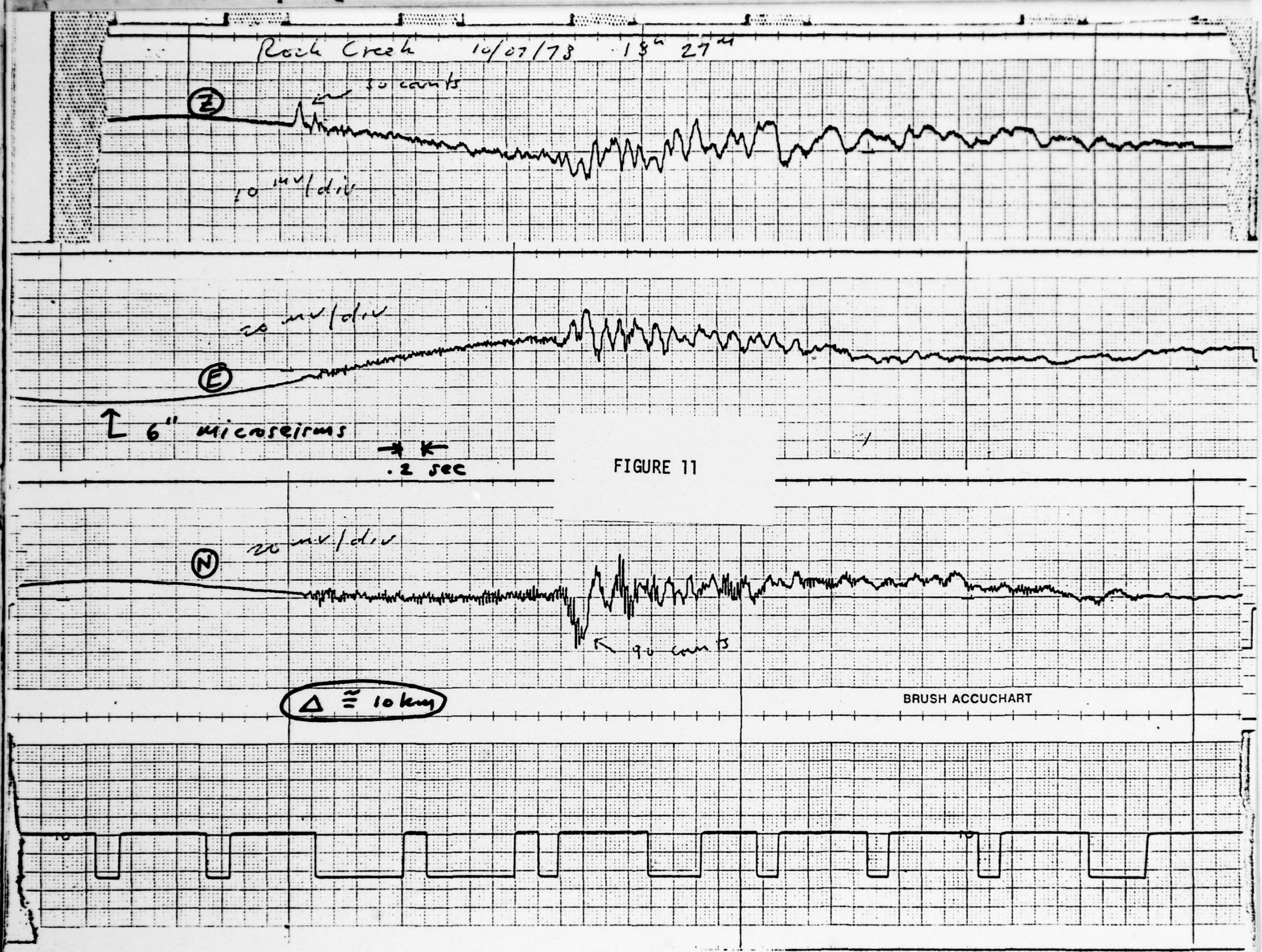

Rock Creek 10/07/78 18h 27m
Z
50 counts
10 mv/div
20 mv/div
E
6" microseisms
.2 sec
20 mv/div
N
90 counts
Δ ≅ 10 km
BRUSH ACCUCHART

FIGURE 11

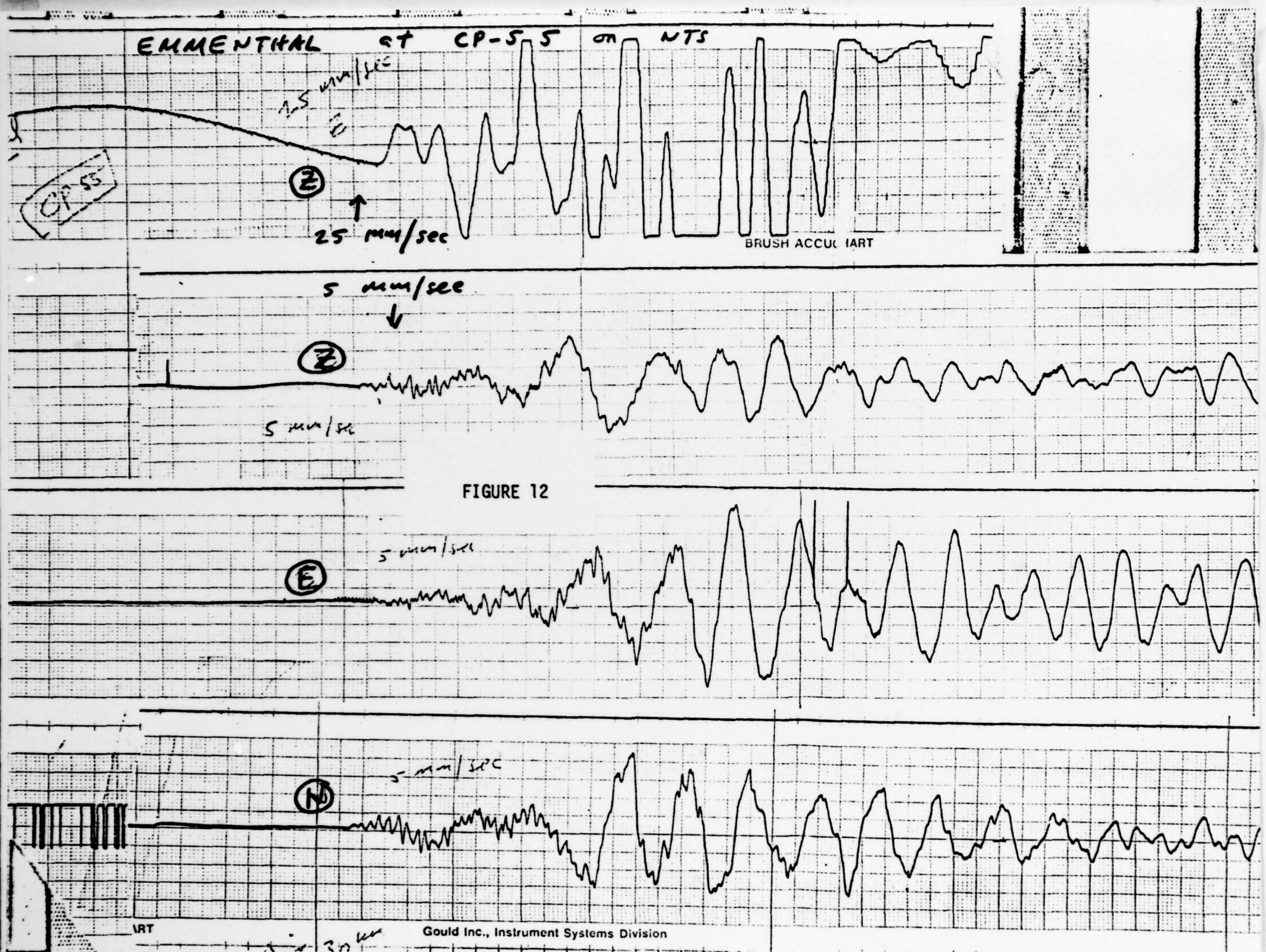

EMMENTHAL at CP-5 5 on NTS
2.5 mm/sec
CP 55
Z
25 mm/sec
BRUSH ACCUCHART
5 mm/sec
Z
5 mm/sec
5 mm/sec
E
5 mm/sec
N
Gould Inc., Instrument Systems Division

FIGURE 12

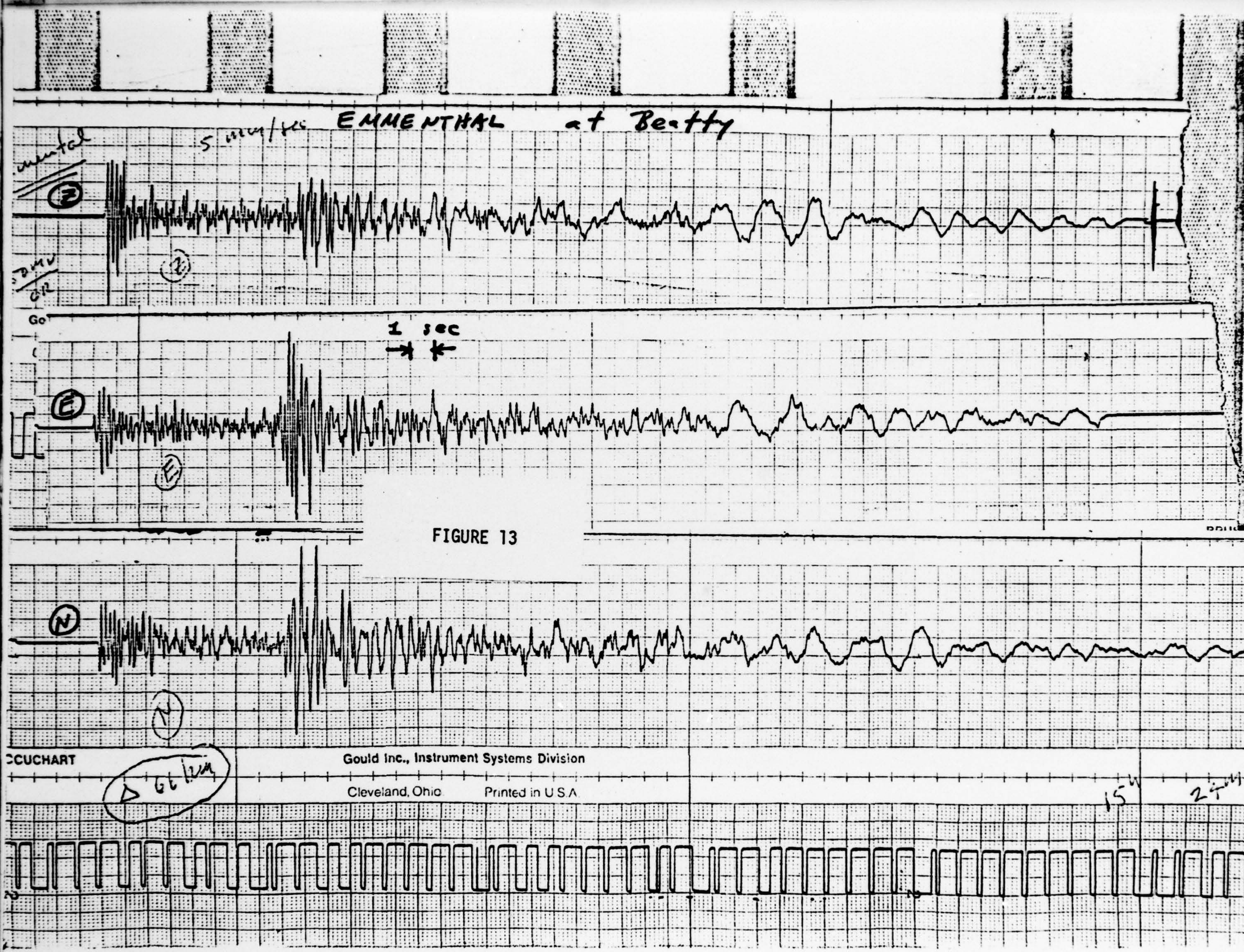

EMMENTHAL at Beatty
5 mm/sec
Z
E
N
1 sec
ACCUCHART
Gould Inc., Instrument Systems Division
Cleveland, Ohio
Printed in U.S.A.

FIGURE 13

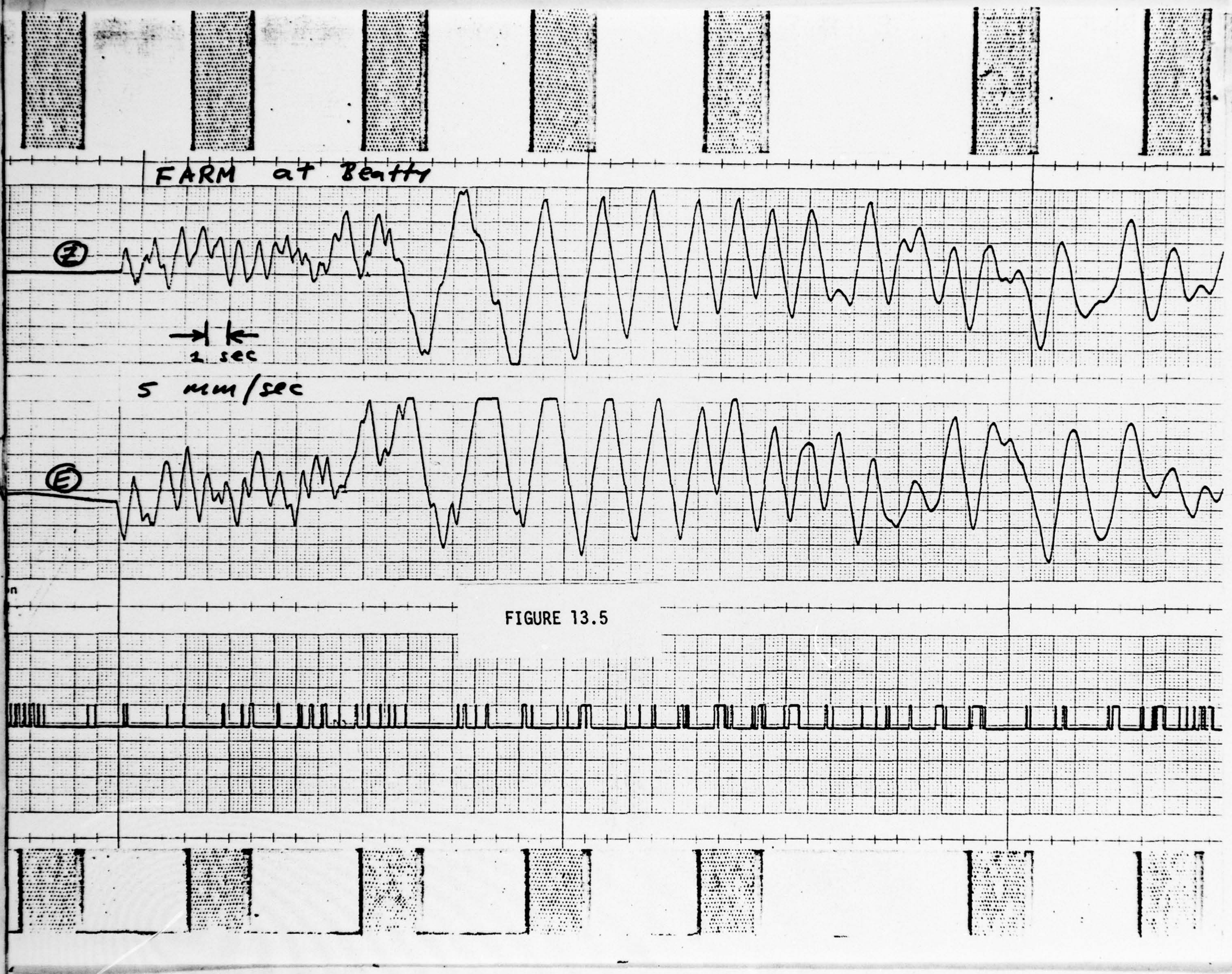


FIGURE 13.5

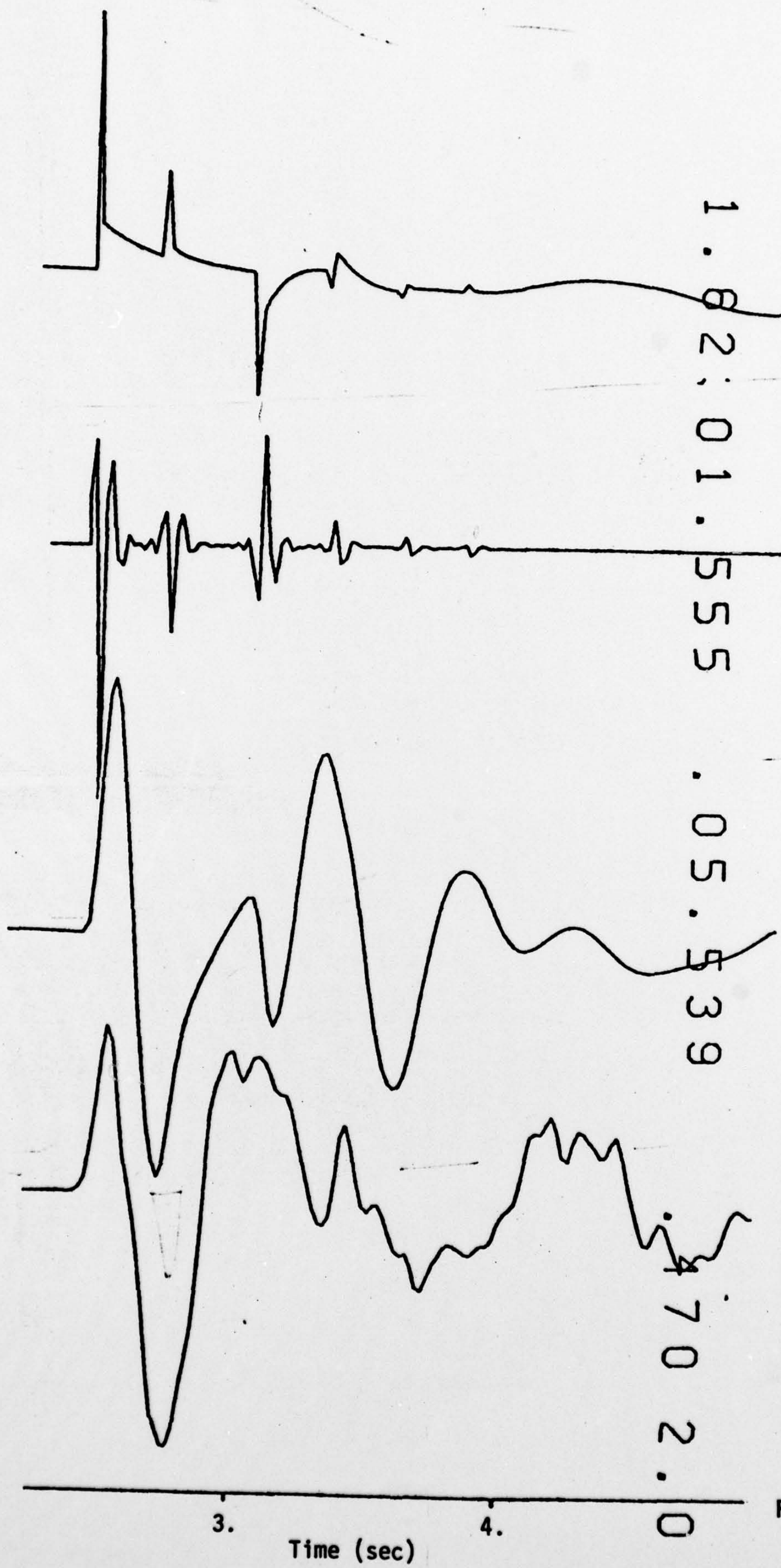


FIGURE 14

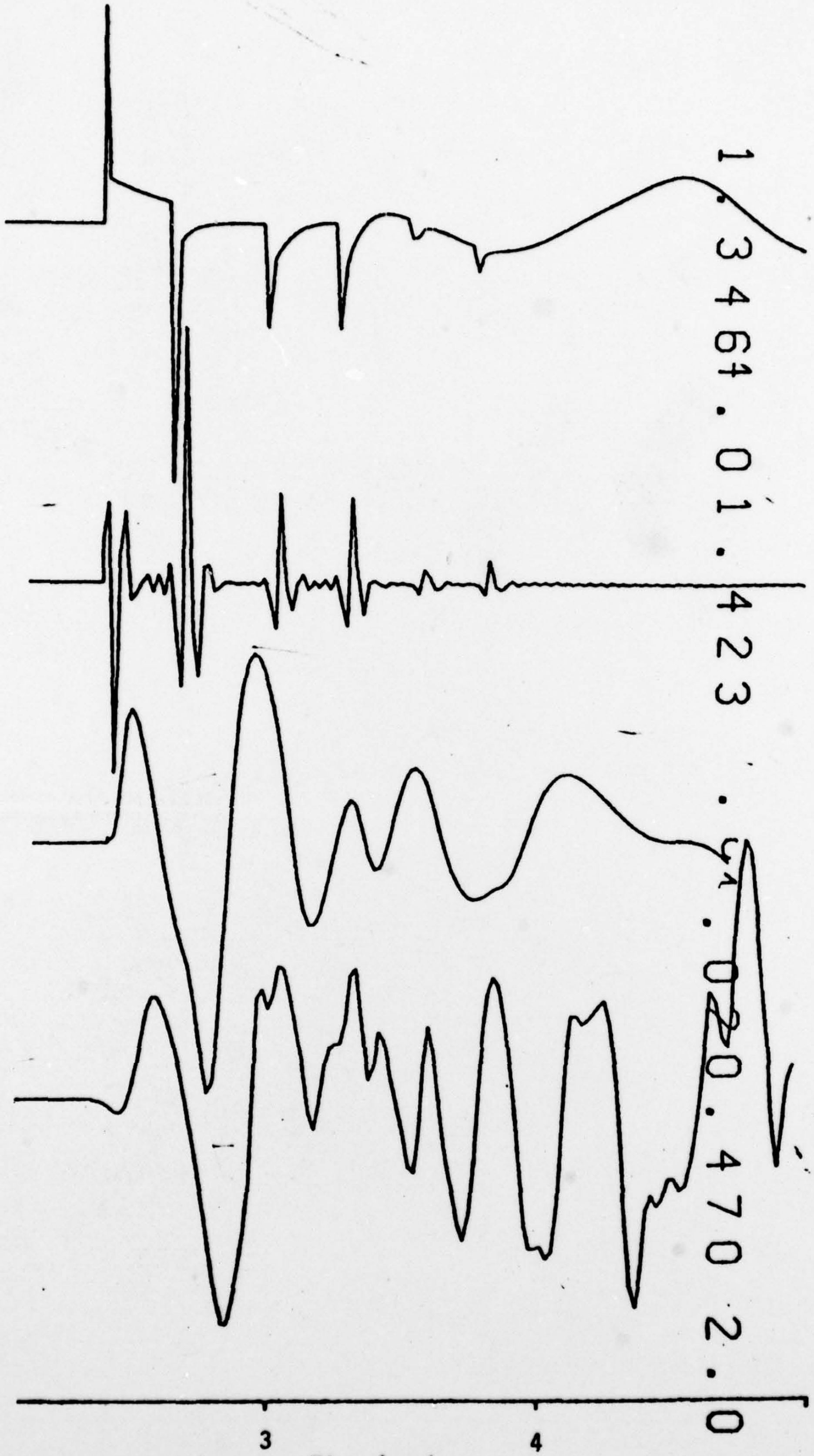


FIGURE 15

Linac Seismic

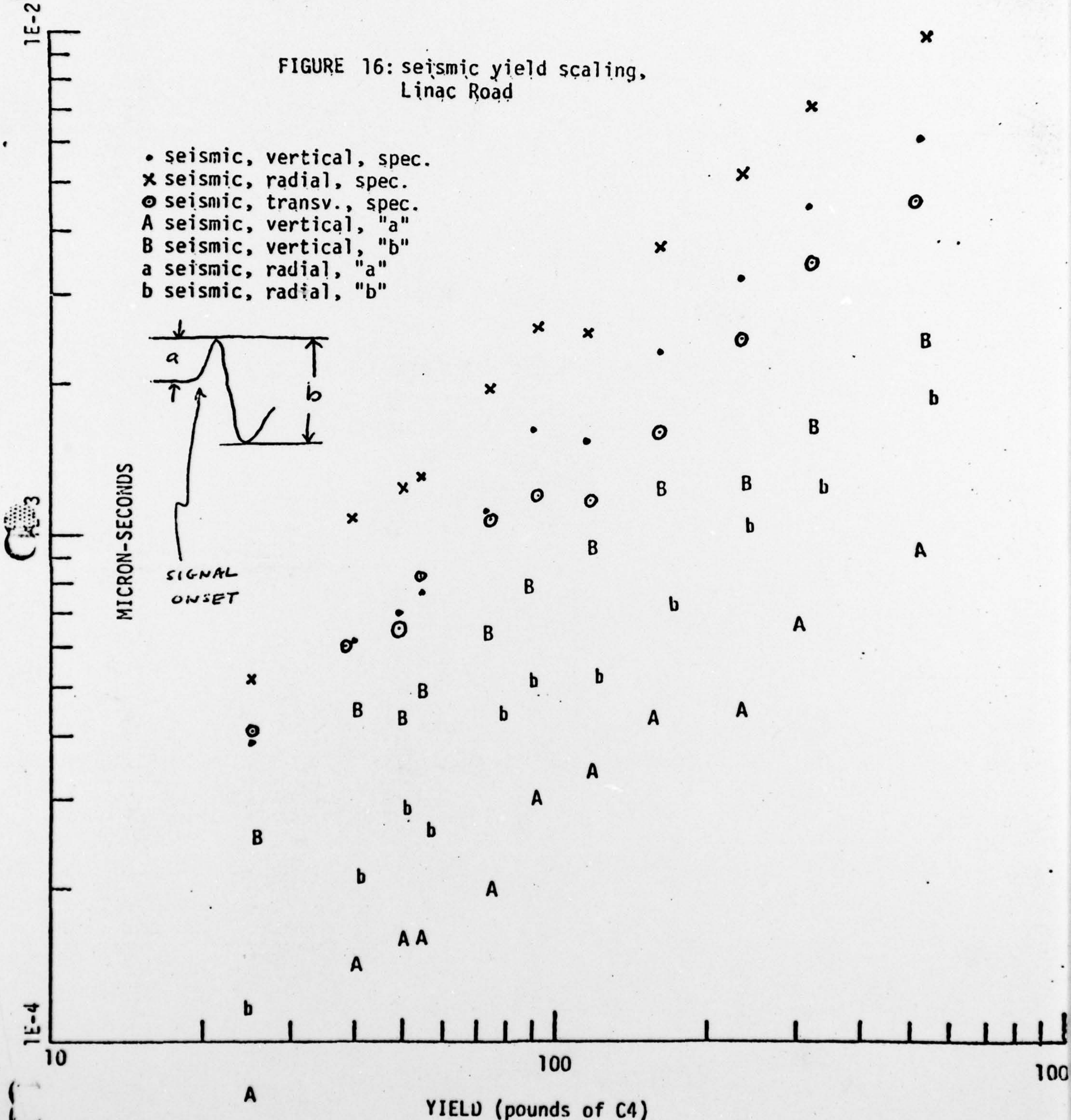


FIGURE 16: seismic yield scaling, Linac Road

TABLE 1.

YIELD SCALING EXPONENTS

LOG A = M LOG Y + B
"A" = AMPLITUDE, "Y" = YIELD

MEASUREMENT	M	UNC.	B	UNC.
LINAC SEISMIC Z 6-9 HZ	.937	.001	-4.70	.002
LINAC SEISMIC R 6-9 HZ	.944	.001	-4.51	.003
LINAC SEISMIC T 6-9 HZ	.798	.001	-4.49	.003
LINAC ACOUST. Z 3-7 HZ	.635	.004	-3.24	.008
LINAC ACOUST. R 3-7 HZ	.710	.006	-3.56	.012
LINAC ACOUST. T 3-7 HZ	.750	.004	-3.31	.009
LINAC SEISMIC Z "A"	.782	.001	1.41	.003
LINAC SEISMIC Z "B"	.725	.001	1.98	.002
LINAC SEISMIC R "A"	.809	.006	1.06	.012
LINAC SEISMIC R "B"	.881	.002	1.46	.003
858 SEISMIC Z 4-9 HZ	.862	.002	-4.70	.003
858 SEISMIC R 4-9 HZ	.880	.003	-5.09	.006
858 SEISMIC T 4-9 HZ	.798	.003	-4.76	.006
858 ACOUST. Z 1.5-3 HZ	.735	.002	-3.57	.005
858 ACOUST. R 1.5-3 HZ	.925	.008	-3.90	.015
858 ACOUST. T 1.5-3 HZ	.908	.005	-4.06	.010
858 SEISMIC Z "A"	.815	.011	1.31	.022
858 SEISMIC Z "B"	.725	.004	1.89	.008
845 SEISMIC Z 8-12 HZ	.695	.003	-3.76	.006
845 SEISMIC R 9-12 HZ	.820	.006	-3.46	.011
845 SEISMIC T 9-12 HZ	1.25	.046	-4.43	.093
845 ACOUST. Z 5-10 HZ	.847	.007	-3.54	.014
845 ACOUST. R 5-20 HZ	.659	.010	-3.16	.020
845 SEISMIC Z "A"	.608	.002	2.46	.005
845 SEISMIC Z "B"	.590	.002	2.96	.005
845 SEISMIC R "A"	.962	.004	1.65	.009
845 SEISMIC R "B"	.944	.003	2.23	.005

incorrectly computed